PCT

WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 6 : H04B 7/005 — A2

(11) International Publication Number: WO 99/53628

(43) International Publication Date: 21 October 1999 (21.10.99)

(21) International Application Number: PCT/FI99/00248

(22) International Filing Date: 25 March 1999 (25.03.99)

(30) Priority Data:
980703 27 March 1998 (27.03.98) FI

(71) Applicant *(for all designated States except US)*: NOKIA TELECOMMUNICATIONS OY [FI/FI]; Keilalahdentie 4, FIN-02150 Espoo (FI).

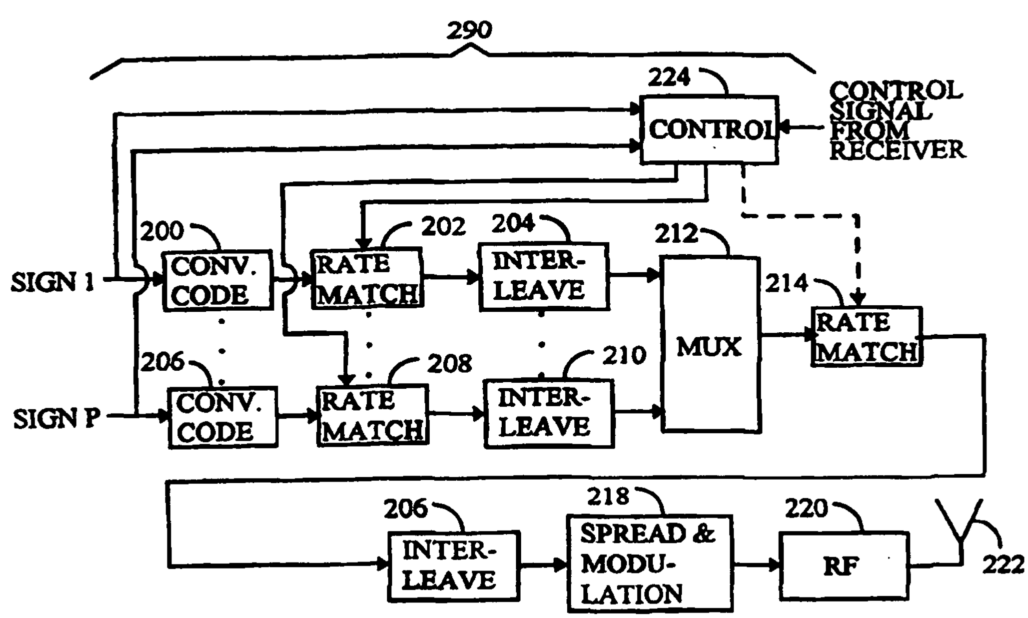
(72) Inventors; and
(75) Inventors/Applicants *(for US only)*: TOSKALA, Antti [FI/FI]; Katajaharjuntie 4 C 48, FIN-00200 Helsinki (FI). HOLMA, Harri [FI/FI]; Itätuulenkuja 1 B 32, FIN-02100 Espoo (FI). RIKKINEN, Kari [FI/FI]; Lindalintie 4 C 22, FIN-02400 Kirkkonummi (FI). PEHKONEN, Kari [FI/FI]; Ranta-Koskelantie 3 B 7, FIN-90570 Oulu (FI).

(74) Agent: PATENTTITOIMISTO TEKNOPOLIS KOLSTER OY; c/o Kolster Oy Ab, Iso Roobertinkatu 23, P.O. Box 148, FIN-00121 Helsinki (FI).

(81) Designated States: AE, AL, AM, AT, AT (Utility model), AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, CZ (Utility model), DE, DE (Utility model), DK, DK (Utility model), EE, EE (Utility model), ES, FI, FI (Utility model), GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SK (Utility model), SL, TJ, TM, TR, TT, UA, UG, US, UZ, VN, YU, ZA, ZW, ARIPO patent (GH, GM, KE, LS, MW, SD, SL, SZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).

Published
In English translation (filed in Finnish).
Without international search report and to be republished upon receipt of that report.

(54) Title: DATA COMMUNICATION AND RADIO SYSTEM



(57) Abstract

The invention relates to a data transmission method and a CDMA system implementing the method. A base station and a terminal of the radio system communicate with each other over a physical channel based on a spreading code. Over the physical channel, a transmitter (190) transmits at least two signals (SIGN 1 – SIGN P) having differing quality requirements when received, and the transmitter (190) changes, if necessary, the symbol rates of the signals (SIGN 1 – SIGN P) signal-specifically by a coder (202, 208) in order to meet quality requirements.

FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AL	Albania	ES	Spain	LS	Lesotho	SI	Slovenia
AM	Armenia	FI	Finland	LT	Lithuania	SK	Slovakia
AT	Austria	FR	France	LU	Luxembourg	SN	Senegal
AU	Australia	GA	Gabon	LV	Latvia	SZ	Swaziland
AZ	Azerbaijan	GB	United Kingdom	MC	Monaco	TD	Chad
BA	Bosnia and Herzegovina	GE	Georgia	MD	Republic of Moldova	TG	Togo
BB	Barbados	GH	Ghana	MG	Madagascar	TJ	Tajikistan
BE	Belgium	GN	Guinea	MK	The former Yugoslav	TM	Turkmenistan
BF	Burkina Faso	GR	Greece		Republic of Macedonia	TR	Turkey
BG	Bulgaria	HU	Hungary	ML	Mali	TT	Trinidad and Tobago
BJ	Benin	IE	Ireland	MN	Mongolia	UA	Ukraine
BR	Brazil	IL	Israel	MR	Mauritania	UG	Uganda
BY	Belarus	IS	Iceland	MW	Malawi	US	United States of America
CA	Canada	IT	Italy	MX	Mexico	UZ	Uzbekistan
CF	Central African Republic	JP	Japan	NE	Niger	VN	Viet Nam
CG	Congo	KE	Kenya	NL	Netherlands	YU	Yugoslavia
CH	Switzerland	KG	Kyrgyzstan	NO	Norway	ZW	Zimbabwe
CI	Côte d'Ivoire	KP	Democratic People's	NZ	New Zealand		
CM	Cameroon		Republic of Korea	PL	Poland		
CN	China	KR	Republic of Korea	PT	Portugal		
CU	Cuba	KZ	Kazakstan	RO	Romania		
CZ	Czech Republic	LC	Saint Lucia	RU	Russian Federation		
DE	Germany	LI	Liechtenstein	SD	Sudan		
DK	Denmark	LK	Sri Lanka	SE	Sweden		
EE	Estonia	LR	Liberia	SG	Singapore		

DATA COMMUNICATION AND RADIO SYSTEM

FIELD OF THE INVENTION

The invention relates to a data transmission method, which is used in a radio system comprising at least one base station and terminal equipment comprising a receiver and a transmitter and communicating with each other over at least one physical channel.

The invention further relates to a radio system, particularly a radio system comprising at least one base station and terminal equipment comprising a receiver and a transmitter and communicating with each other over at least one physical channel.

BACKGROUND OF THE INVENTION

Present mobile telephone systems attempt to provide the user with increasingly versatile services. This goal is shared by IMT-2000 (International Mobile Telecommunications for the Year 2000) services which aim to offer high-quality speech/audio signal transmission, high-rate data transfer, photograph transmission and video image transmission. In addition, the IMT-2000 service encompasses interactivity, multimedia electric mail, video conferences and target location determination, for example.

Transferring different data requires different symbol rate and signal transmission power. In the present radio systems the symbol rate is not optimized for the changing channel conditions since the symbol rate of several signals cannot be adapted in one physical channel. If, for example, two service signals transmitted over the same physical channel have differing quality requirements when received and the signals act differently when the delay profile of the channel changes, problems affecting the power level of the two signals occur. Such a problem typically arises when Reed-Solomon coding and convolution coding are used together. When the channel delay profile changes, a situation may arise when the first signal in accordance with the example is barely acceptable in terms of quality, while the other signal is of unnecessarily high quality. The situation is particularly critical when a service signal only requiring a low symbol rate forces a service signal requiring a high symbol rate to use extra transmission power. The prior art solutions fail to resolve this disparity. Unresolved, the disparity will cause interference over the whole area of the radio system.

BRIEF DESCRIPTION OF THE INVENTION

An object of the invention is thus to provide a method and a radio system implementing the method so as to solve the above problems and balance the signal quality. This is achieved by a method of the type described in the introduction, the method being characterized by the transmitter transmitting at least over one physical channel at least two signals having differing quality requirements when received, and the transmitter changing, if necessary, signal-specifically the symbol rates of the signals used over the physical channel in order to meet the quality requirements.

The radio system of the invention is characterized by the transmitter being arranged to transmit over one physical channel at least two signals having differing quality requirements when received, the transmitter therefore comprising at least means for changing the symbol rate of the signals signal-specifically in order to meet the quality requirements, and combination means for combining the signals in the same physical channel.

A plurality of advantages can be achieved with the method and system of the invention. The desired quality requirements of a signal to be received can be balanced, which enables optimized transmission power be used. The result is less interference in the radio system.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention is now described in closer detail in connection with the preferred embodiments with reference to the accompanying drawings, in which

Figure 1 shows a prior art transmitter,

Figure 2 shows a transmitter of the invention, and

Figure 3 shows a transceiver of the invention.

DETAILED DESCRIPTION OF THE INVENTION

The solution of the invention is suited particularly for WCDMA (Wideband Code Division Multiple Access), UMTS (Universal Mobile Telephone System) and IMT-2000 radio systems. Hence, the invention is suitable for at least TDMA-based (Time Division Multiple Access) and CDMA-based radio systems.

Examine first by means of Figure 1 how data is transmitted in accordance with the prior art. In the present example, a transmitter 90 only

transmits a signal 1 and a signal 2 over the same physical channel, but the same principle applies also to three or more signals to be transmitted. The signals typically have differing quality standards when received. A carrier-to-interference ratio or for instance a bit error rate BER can be used as the quality standard. The BER of the signal 1 is for example BER1 = e^{-3} and the BER of the signal 2 is BER2 = e^{-6}. Since the quality requirements are signal-specific, the signals should be transmitted at different transmission powers/symbol rates. The signal 2 to be transmitted is first encoded by for example Reed-Solomon coding at means 100. This coding can also be some other coding. Next, at means 102, the signal 2 is interleaved, in other words the bits or symbols of the signal are rearranged such that the signal 2 becomes more tolerant of fadings. The signal 1 and the signal 2 are combined into a combined signal at a combination means 104, which can be a multiplexer. Next, the combined signal is convolution-coded at a coder 106. The symbol rate - and thus also the transmission power - of the combined signal is changed by removal coding or repetition coding, if necessary, at means 108. The removal coding or repetition coding increases or decreases the number of bits to be transmitted, affecting the two signals in a similar manner. The signal is further interleaved at means 110. Eventually, the signal is modulated into a radio-frequency signal at radio frequency means 114 in a manner obvious to one skilled in the art, and the radio-frequency signal is transmitted by an antenna 116. The fact that only one shared unit 108 is provided to adapt the symbol rate prevents the signal power levels from being optimized.

Examine now a solution of the invention by means of Figure 2. A transmitter 190 transmits a total of P signals having differing quality requirements. The number P of the signals to be transmitted is two or more. Before being combined, a signal 1 is encoded by a coder 200, the symbol rate is adapted at means 202 and interleaved at means 204. Other signals are processed in a similar manner; a signal P is thus encoded at a coder 206, the symbol rate is adapted at means 208 and interleaved at means 210. Although being typically employed in a radio system transmitter, the coders 200, 206 and the interleaving means 204, 210 are irrelevant to the invention. Hence, in addition to or instead of the coders 200, 206 and the interleaving means 204, 210, the solution of the invention can further comprise other signal processing means. Essential in the inventive solution is that the signals in this embodiment at least have the unique means 208 and 210 affecting the symbol rate

which change the symbol rate by removal coding and/or repetition coding, if necessary. Changing the symbol rate also changes the signal transmission power; changing the symbol rate is thus equivalent to changing signal transmission power. The signals are combined at a combination means 212, which is a multiplexer. In the solution of the invention, the symbol rate of the combined signal can be further changed at means 214, if necessary, the means 214 also performing removal coding and/or repetition coding. In the solution of the invention, it is not, however, necessary to change the symbol rate at this point. The subsequent operation of the transmitter 190 is irrelevant to the inventive solution. Typically, however, the signal is interleaved at means 216, spreading-coded and modulated in one or more manners at means 218, modulated into a radio-frequency signal at means 220, and transmitted via an antenna 222. Hence, at least two different signals that are usually associated with different services are transmitted over the same physical channel. A physical channel is here defined as a channel based on the use of one or more spreading codes.

In a preferred embodiment of the invention the symbol rate of the transmitter 190 can be controlled by a receiver. In such a case, a control signal (CONTROL SIGNAL FROM RECEIVER) is supplied from the receiver to a control unit 224 of the transmitter, the control unit controlling the blocks 202, 208 changing the symbol rate as instructed by the control signal. The control block 224 can also control the block 214 changing the symbol rate if such a block is in use at the transmitter 190. The signals 1 to P are also supplied to the control block 224, whereby the control block 224 knows the required symbol rate. Removal coding and/or repetition coding changing the symbol rate and the transmission power is performed both for the transmitter and the receiver in a known manner. Consequently, the change does not otherwise affect the data transmission.

Figure 3 shows the features of the inventive solution in greater detail. The base stations and terminal equipment of the radio system are transceivers, the block diagram of Figure 3 showing such a transceiver in general. The transceiver transmits P signals, which a transmitter 290 first encodes at means 300, 306, adapts the symbol rates at means 302, 308, and interleaves at means 304, 310 as in Figure 2. Henceforth, the signal processing also proceeds in accordance with Figure 2, in other words the signals are combined by a combination means 312, the symbol rate of the combined signal is further

adapted at means 314, and the combined signal is interleaved at means 316. Next, at a typical transmitter part 290, control data is added to the signal to be transmitted at means 318, preferably being a multiplexer. Next, the signal is spreading-coded, which is performed in such a manner that the signal is multiplied at a multiplier 322 by a spreading code supplied from a spreading code generator 320. The spreading-coded signal is modulated into a radio-frequency signal by multiplying at a multiplier 326 the signal by a carrier supplied from an RF oscillator 324 and by filtering the signal at a filter 328. The radio-frequency signal is amplified at an RF power amplifier 330 and transferred via a duplex-filter 332 to an antenna 334 to be transmitted.

In the solution of the invention, a receiver 280 operates in the following manner. The antenna 334 receives the signal, which is a combination signal consisting of several signals. The received signal propagates via the duplex-filter 332 to a filter 336, which only allows the desired band to pass. The filtered signal is demodulated by multiplying the signal at a multiplier 340 by the signal of a local oscillator 338, and low-pass-filtering the signal at a filter 344. Next, the aim is to keep the power level of the received signal unchanged with an AGC amplifier 346. The signal is changed to digital by an analogue/digital converter 348. Since the signal is a multipath-propagated signal, the aim is to combine the signal components propagated via different paths in a block 350 which, in accordance with the prior art, comprises a plurality of RAKE branches. The signal components received by the RAKE branches at different delays are searched by correlating the received signal with the spreading codes used, which are delayed by predetermined delays. When the signal component delays are found out, signal components belonging to the same signal are combined. Simultaneously, the spreading coding of the signal components is decoded. Next, the control signals and data signals included in the received signal are separated by demultiplexing at means 352. The signal part containing data is conveyed to be deinterleaved at means 354. Here, the interleaving of the block corresponding to the interleaving means 316 is thus deinterleaved. Next, at means 356, the signal undergoes an inverse operation of the symbol rate change corresponding to the transmitter block 314. Hence, if the transmitter block 314 has performed removal coding, the block 356 performs repetition coding of a corresponding extent. Next, the combination signal is divided into P signals at demultiplexing means 358. The interleaving of the first signal is deinterleaved at deinterleaving means 360, the symbol rate is

inversely adapted in relation to the adaptation of the transmitter block 302 at means 362 and the signal coding is decoded at the means 362, in which case the signal 1 is available to the receiver. A similar procedure is repeated in connection with other demultiplexed signals; similarly, the interleaving of the signal P is deinterleaved at means 366, removal coding or repetition coding is performed at means 368, and the signal is decoded at means 370. The means 300, 306 of the transmitter usually perform convolution coding, the convolution coding being decoded by the means 364, 370 of the receiver.

The receiver 280 further comprises a block 372 measuring the signal quality. If any of the received signals does not meet the quality requirements or exceeds the quality requirements too dramatically, in other words deviates too much from a predetermined quality requirement, a signal controlling the symbol rate is supplied from the block 372 to the block 318 of the transmitter part for the control channel.

The solution of the invention is also suited for radio systems wherein the physical channel is based on bursts instead of spreading code(s), as is the case with the TDMA-based transmissions for example in a GSM radio system. In such a case, a plurality of service signals can be transmitted at an optimal power level in the same burst. The advantage of this is that the receiver does not need to receive separate signals from each service. This also applies to the TDMA/CDMA radio system wherein spreading coding is used within the burst. Hence, several different services can be simultaneously placed for the code or group of codes to be used in the burst. Figures 1 to 3 show transmitters and receivers using spreading coding. Truly TDMA-based transmitters and receivers are similar to the ones shown in Figures 1 to 3 as regards the rest of the blocks, but spreading coding is naturally ignored at the blocks 112, 218, the means 320 and 322 also being unnecessary. Furthermore, neither are the delays of the received signal caused by multipath-propagation searched on the basis of the spreading code at the block 350 in such a case. In the TDMA receiver, the block 350 performs equalization wherein the received signal is multiplied by an estimate of the impulse response of the channel. The impulse response estimate is formed, in turn, by means of a training sequence or another known sequence in a manner obvious to one skilled in the art. Both transmission and reception modes are employed in the TDMA/CDMA transceivers.

Although the invention is described above with reference to the example in accordance with the accompanying drawings, it is obvious that the invention is not restricted thereto but can be modified in various ways within the scope of the inventive idea disclosed in the attached claims.

CLAIMS

1. A data transmission method, which is used in a radio system comprising at least one base station and terminal equipment comprising a receiver (280) and a transmitter (90, 190, 290) and communicating with each other over at least one physical channel, the method being **characterized** by the transmitter (190, 290) transmitting at least over one physical channel at least two signals (SIGN 1 - SIGN P) having differing quality requirements when received, and the transmitter (190, 290) changing, if necessary, signal-specifically the symbol rates of the signals (SIGN 1 - SIGN P) used over the physical channel in order to meet the quality requirements.

2. A method as claimed in claim 1, **characterized** by the transmitter (190, 290) changing the symbol rates of the signals (SIGN 1 - SIGN P) employing removal coding and/or repetition coding.

3. A method as claimed in claim 2, **characterized** by the removal coding and repetition coding being performed for the transmitter (190, 290) and the receiver (280) in a predetermined manner, whereby the change in the symbol rate does not interfere with the data transmission.

4. A method as claimed in claim 1, **characterized** by the transmitter (190, 290) combining the signals (SIGN 1 - SIGN P) to be transmitted into a combined signal, the symbol rate of each signal (SIGN 1 - SIGN P) being changed before the combination in such a way that the symbol rate of the combined signal is kept unchanged.

5. A method as claimed in claim 1, **characterized** by the receiver (280) indicating to the transmitter (190, 290) that a need exists to change the symbol rates of the signals (SIGN 1 - SIGN P) transmitted by the transmitter (190, 290) when the quality of one or more signals (SIGN 1 - SIGN P) does not meet a predetermined quality requirement at the receiver (280).

6. A method as claimed in claim 1, **characterized** by the transmitter (190, 290) combining the signals (SIGN 1 - SIGN P) to be transmitted, whose symbol rates have been changed, into one signal, and the transmitter (190, 290) also changing, if necessary, the symbol rate of the combined signal.

7. A method as claimed in claim 1, **characterized** by the transmitter (190, 290), in addition to changing the symbol rate, also interleaving the signal.

8. A method as claimed in claim 1, **characterized** by the transmitter (190, 290), in addition to changing the symbol rate, also convolution coding and/or Reed-Solomon coding the signal.

9. A method as claimed in claim 1, **characterized** by the signal quality requirements being signal-specific.

10. A radio system, particularly a radio system comprising at least one base station and terminal equipment comprising a receiver (280) and a transmitter (90, 190, 290) and communicating with each other over at least one physical channel, the radio system being **characterized** by the transmitter (190, 290) being arranged to transmit over one physical channel at least two signals (SIGN 1 - SIGN P) having differing quality requirements when received, the transmitter (190, 290) therefore comprising at least

means (202, 208, 302, 308) for changing the symbol rate of the signals (SIGN 1 - SIGN P) signal-specifically in order to meet the quality requirements, and

combination means (212, 312) for combining the signals in the same physical channel.

11. A radio system as claimed in claim 10, **characterized** by the means (202, 208, 302, 308) for changing the symbol rates of the signals (SIGN 1 - SIGN P) being arranged to employ removal coding and/or repetition coding.

12. A radio system as claimed in claim 10, **characterized** by the removal coding and/or repetition coding of the means (202, 208, 302, 308) being known to the transmitter (190, 290) and the receiver (280).

13. A radio system as claimed in claim 10, **characterized** by the combination means (212, 312) combining the signals (SIGN 1 - SIGN P) into a combined signal and the means (202, 208, 302, 308) being arranged to change the symbol rate of each signal before the combination in such a way that the symbol rate of the combined signal is unchanged.

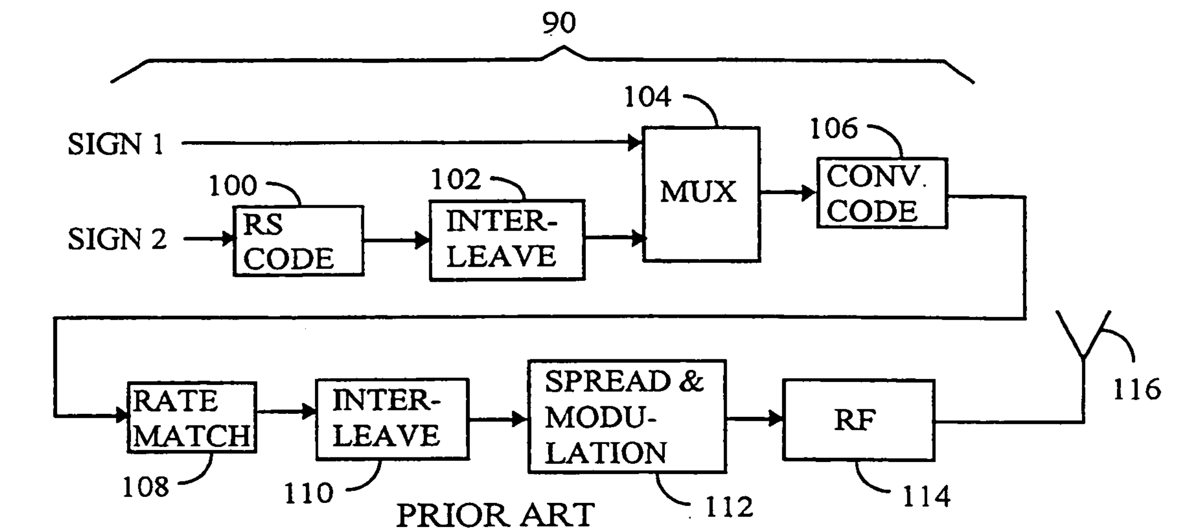
14. A radio system as claimed in claim 10, **characterized** by the receiver (280) comprising means (372) for measuring the quality of the signals (SIGN 1 - SIGN P) and the receiver (280) being arranged to indicate to the transmitter (190, 290) that a need exists to change the symbol rates of the signals (SIGN 1 - SIGN P) transmitted by the transmitter (190, 290) when the quality of one or more of the signals (SIGN 1 - SIGN P) does not meet a predetermined quality requirement at the receiver (280).

15. A radio system as claimed in claim 10, **characterized** by the combination means (121, 213) being arranged to combine the signals (SIGN 1 - SIGN P) whose symbol rates have been changed into a combined signal, and the transmitter (190, 290) comprising means (314) to change, if necessary, also the symbol rate of the combined signal.

16. A radio system as claimed in claim 10 or 15, **characterized** by the transmitter (190, 290) comprising, in addition to the means (202, 208, 302, 308, 314) for changing the symbol rate, means (204, 210, 304, 310, 316) for interleaving the signals.

17. A radio system as claimed in claim 10 or 15, **characterized** by the transmitter (190, 290) comprising, in addition to the means (202, 208, 302, 308, 314) for changing the symbol rate, means (200, 206, 300, 306) for convolution coding and/or Reed-Solomon coding the signals (SIGN 1 - SIGN P).

18. A radio system as claimed in claim 10, **characterized** by the quality requirements of the signals (SIGN 1 - SIGN P) being signal-specific.



PRIOR ART

FIG. 1

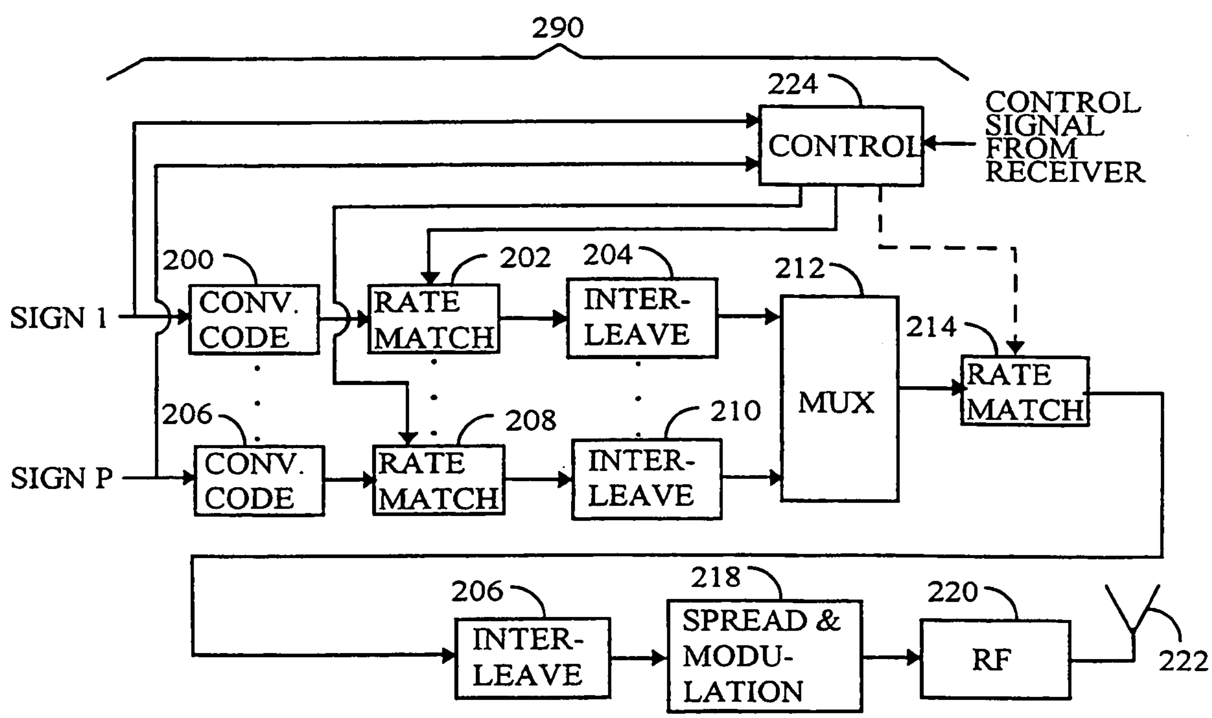
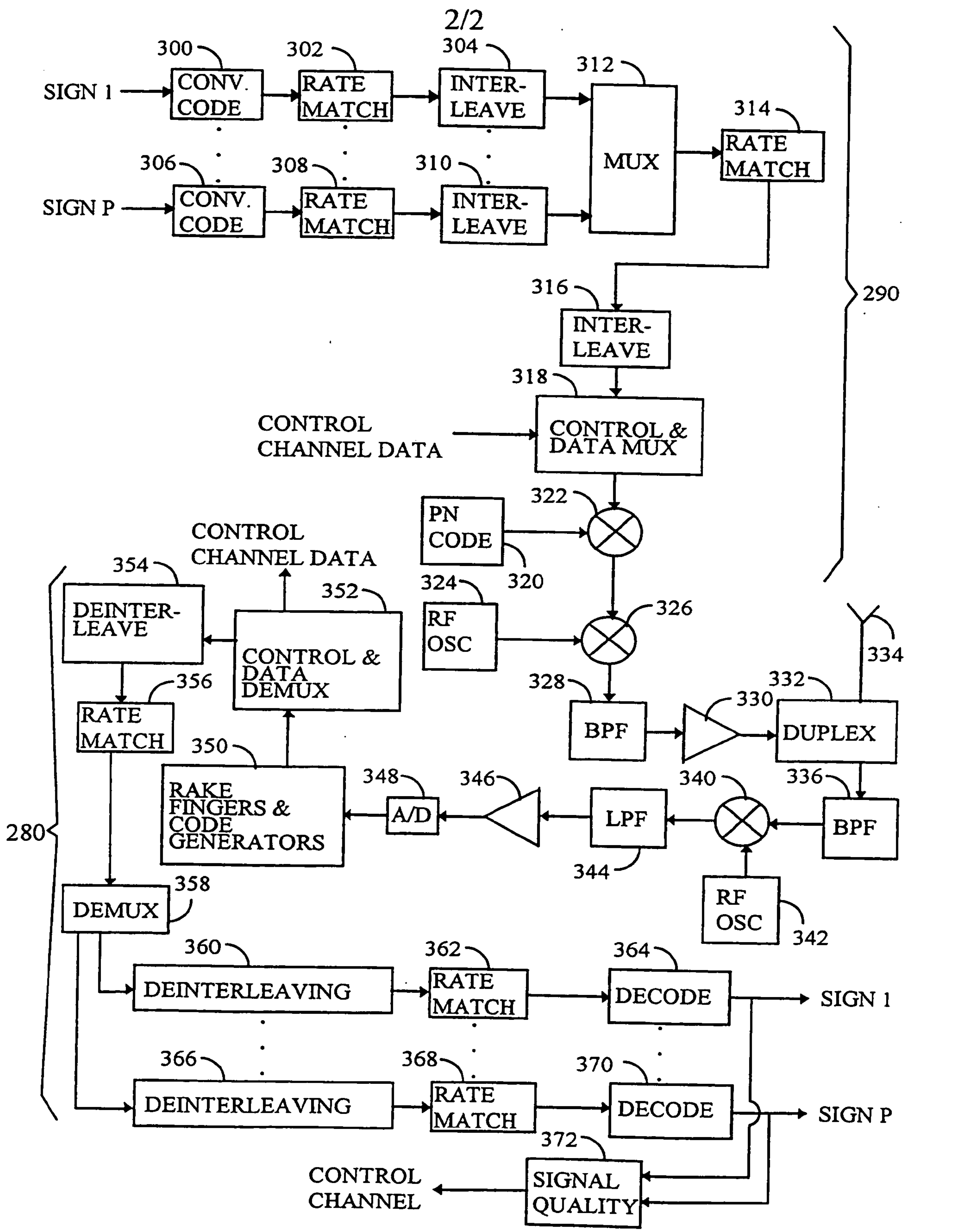


FIG. 2



SIGN 1
300
CONV. CODE
302
RATE MATCH
304
INTER-LEAVE
312
MUX
314
RATE MATCH
SIGN P
306
CONV. CODE
308
RATE MATCH
310
INTER-LEAVE
316
INTER-LEAVE
290
318
CONTROL CHANNEL DATA
CONTROL & DATA MUX
322
PN CODE
320
324
RF OSC
326
328
BPF
330
332
DUPLEX
334
CONTROL CHANNEL DATA
354
DEINTER-LEAVE
352
CONTROL & DATA DEMUX
356
RATE MATCH
350
RAKE FINGERS & CODE GENERATORS
348
A/D
346
LPF
344
340
336
BPF
RF OSC
342
280
DEMUX
358
360
DEINTERLEAVING
362
RATE MATCH
364
DECODE
SIGN 1
366
DEINTERLEAVING
368
RATE MATCH
370
DECODE
SIGN P
372
CONTROL CHANNEL
SIGNAL QUALITY

FIG. 3